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FORECASTING THE SILVER HAKE FISHERY IN THE NOVA SCOTIA SHELF, CANADA

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ABSTRACT

In 1980 an 8-year study was begun of the behaviour of warm water incursions which occur in the Nova Scotia Shelf during the summer. Near-bottom temperatures at a station located at 40°57'.7N and 63°18'.5W in the central zone of the shelf were found to reflect the volumes of warm water that entered the bank, and the areas in which the best concentrations of silver hake (Merluccius bilinearis) have been found are located on the periphery of these waters. Using a linear function (Y = 12.75 + 1.99 X) the total area occupied by these waters can be determined in thousands of square nautical miles, based on the near-bottom temperatures in degrees Celsius detected at the station in question. Once the latter area is known, the peripheral area can be estimated by comparing the results obtained with working figures and data to gain an idea of the zones with the best prospects for fishing operations.

INTRODUCTION

The short term (annual) temperature fluctuations in the Nova Scotia Shelf have not been fully studied. Among the authors who have dealt with the subject, Lauzier (1965) has made a very interesting investigation of long-term trends in surface and bottom temperature

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variations in the Nova Scotia Shelf. His work presents water-temperature trends from 1921 to 1962, and periods of cooling and warming were observed at different points. However, he makes no exhaustive study of annual temperature variations, and his stratification of the water column is vague, since he mentions only a minimum temperature layer at from 50 to 60 m deep.

In addition to long-term fluctuations, incursions of warm water into the shelf, which are more intense during the summer, cause annual or short-term fluctuations. The summer incursions are not uniform along the entire Shelf, and apparently occur in certain propitious zones. The central area of the platform, between 61°and 64° west longitude, is the zone into which the largest volume of water penetrates. The water penetrates from the east through a canyon called Gully and the southeast of Sable Island; from the west it penetrates through the southern and western zones of Browns Bank (C. Garcia, in press).

The volumes of warm water that enter each year are different, producing marked temperature variations (mentioned above) whose cycle is not yet known. High heat content causes a warm year; average values a normal year; and low content a cold year (Lauzier, 1965; Bailey, 1975; Karasiov, manuscript).

In the summer, when warm waters enter the Shelf, the silver hake come up to spawn, and this is the most intense period of the fishery. Therefore, since the species responds to a mass of warm water, it is logical to think that the greater the mass of warm water in Shelf the higher the probabilities that the species will enter and can spawn unhampered by environmental difficulties, making it possible to forecast the fishery using water temperatures.

MATERIALS AND METHODS

Temperature charts for 1976-1978 (Garcia, in press), together with those of Scott (1976) for 1970-1974 were used to prepare a short-term fisheries forecast, based on an 8-year series in which only one year, 1975, was not recorded.

Keeping in mind that the isotherm of 8°C marks the lower limit of warm waters and that of 6°C marks the upper limit of cold waters (Gonzales and Leal, manuscript), the areas in the Shelf occupied by warm waters were delimited for each year in the series, in square nautical miles.

A temperature analysis was performed using isothermal charts, for the purpose of determinating where a station to detect temperature fluctuations should be located. To do so, a zone was chosen in the central part of the Shelf which registered the highest near-bottom temperatures in years of large influxes of warm water, and which also reflected the presence of warm waters in years of low intensity. Various points were located in this zone and their annual temperature values were compared to the areas occupied by warm waters in these years. The results showed that the point at 42°57'.7N and 63°18'.5W was the most representative of this ratio.

The linear regression for the temperature values at the station and in the area, and the correlation coefficient were calculated. The X^2 (chi square) test was applied to the equation obtained (Table 1).

The results for the silver hake catch obtained by Scott (1976) for the years 1970-1974 are presented in the form of isolines (Figure 1). The annual commercial catch for this species was taken from ICNAF reports (1979).

RESULTS AND CONCLUSIONS

A detailed analysis of the near-bottom temperature charts for all the years in question presents some interesting features.

One: The largest volume of water that enters the Shelf does so through the central zone which coincides with Garcia's earlier findings (manuscript) (Figs. 2-9).

Two: When incursions in the central zone increase, they drop in the eastern and western zones, and vice-versa (Figs. 7-9).

Three: Independently of the volume of water that enters the central zone, this zone will show the highest temperature values.

Four: The temperatures of near-bottom waters in the central part of the shelf close to the slope are in direct ratio to the volumes of water that enter.

The linear regression $Y = 12.75 + 1.99\ X$, in which the independent variable is near-bottom temperature at the station in question, and the dependent variable is the total area of the shelf occupied by warm waters, is highly significant in the non-parametrical test (X^2 8.95% = 14.1-2.466) and the correlation coefficient 0.87 is significant to a probability of 0.99, which is excellent if we consider the imprecisions produced by interpolating the temperatures of the isolines and calculating the areas enclosed by them.

It has already been mentioned that silver hake prefer the warm waters in the Shelf over larger volumes of water. When warm waters enter, there is a higher probability that the hake will appear. Spawning conditions will also be better.

Comparing Figure 1 with the temperature charts it can be seen that silver hake were caught in the areas occupied by warm waters, with a preference for the frontal zone.

When an attempt is made to predict the catch or yield of a species using the parameters of the medium, the condition of the stock must be optimum, otherwise the results would not reflect reality. However, once the zones with the best fishing potential are determined, they are independent of the condition of the stock.

Comparing the catch for this species reported with ICNAF and the areas occupied by warm water from the year 1970 to 1976 (when the mesh size for commercial operations was changed) it can be seen that the both the catch and the area increased from 1970 to 1973. After the latter year, in which the maximum catch was obtained, the values for the catch begin to drop while the areas continue to increase until 1976. This behaviour makes it impossible to predict total catch.

If near-bottom temperatures during the summer are obtained for the station and the area is calculated using the equation given, the results can be compared with those obtained during the 8 years and the approximate periphery of the area occupied by warm waters can be determined. The most promising zone for fishing operations is found to the west of this periphery, in the central region of the shelf.

This kind of forecast would increase the operational efficiency of the fishing fleet, by pointing out the areas with the best prospects, independently of the abundance of the species.

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Table 1. Fishing forecast for the Nova Scotia Shelf, Canada

Year	Temp. °C near bottom	Area $mn^2 \cdot 10^3$	Catch $t \cdot 10^5$	Estimated Area $mn^2 \cdot 10^3$
1970	8.0	3.60	1.69	3.17
1971	10.2	5.24	1.29	7.55
1972	10.8	6.10	1.15	8.74
1973	11.0	9.93	2.99	9.14
1974	12.0	11.62	0.95	11.13
1976	12.6	13.00	0.97	12.32
1977	10.1	9.56		7.35
1978	9.3	6.56		5.76

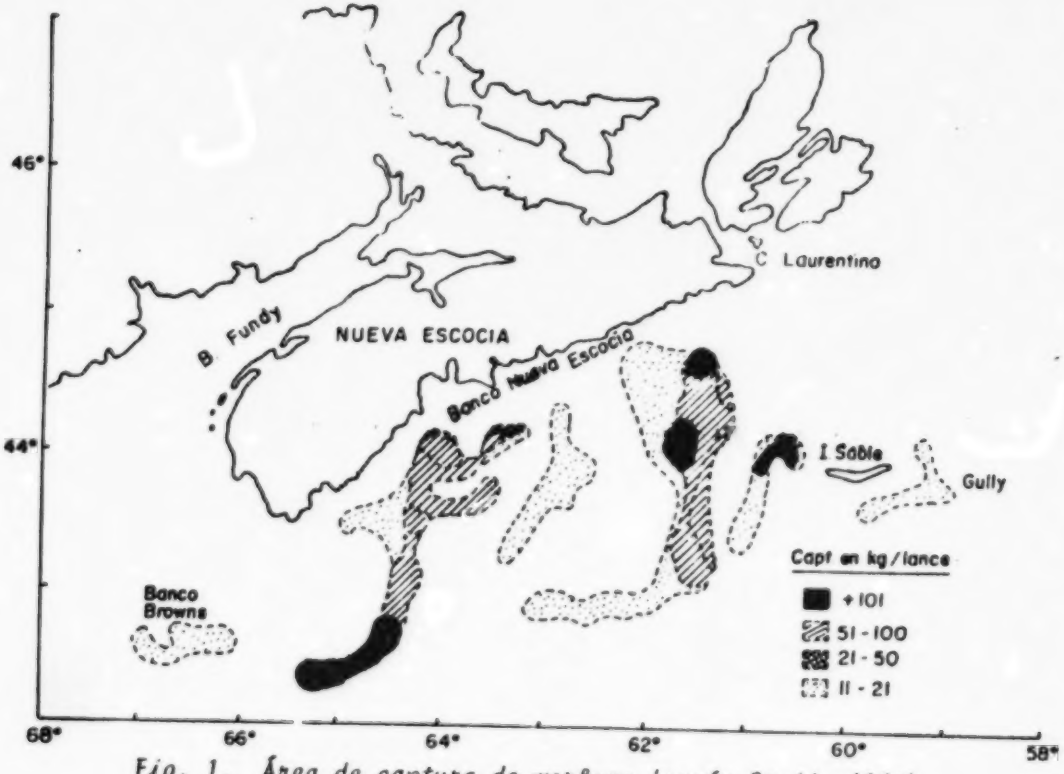


Fig. 1. Área de captura de merluza (según Scott, 1976).

Fig. 1. Silver hake catch area (according to Scott, 1976).

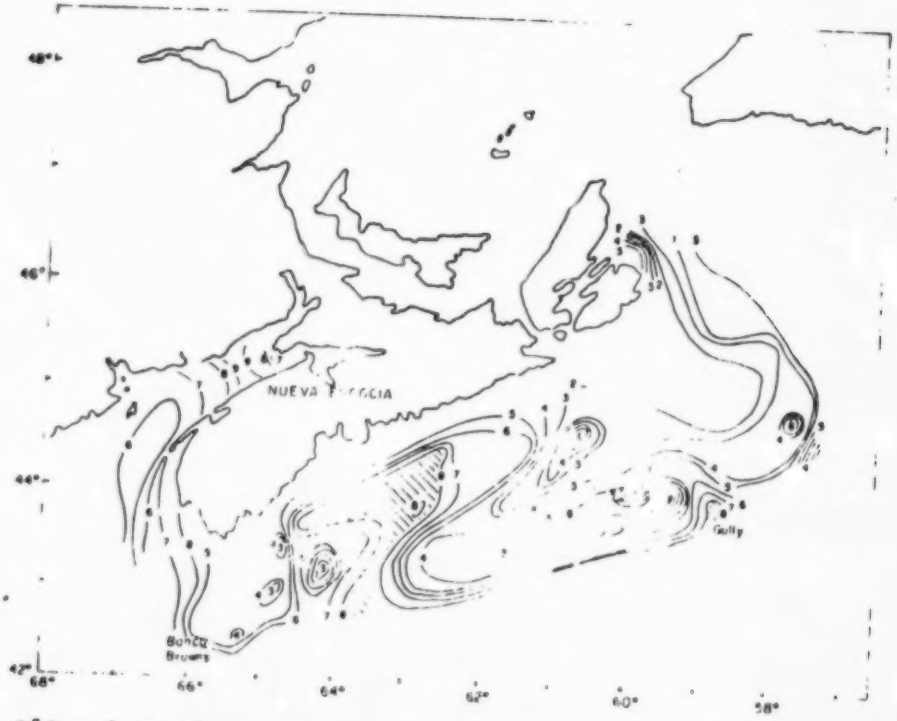


Fig. 2. T°C y áreas de aguas cálidas en el fondo - 1970. (Tomado Scott, 1976).

Fig. 2. T°C and areas with warm bottom waters . (Taken from Scott, 1976)

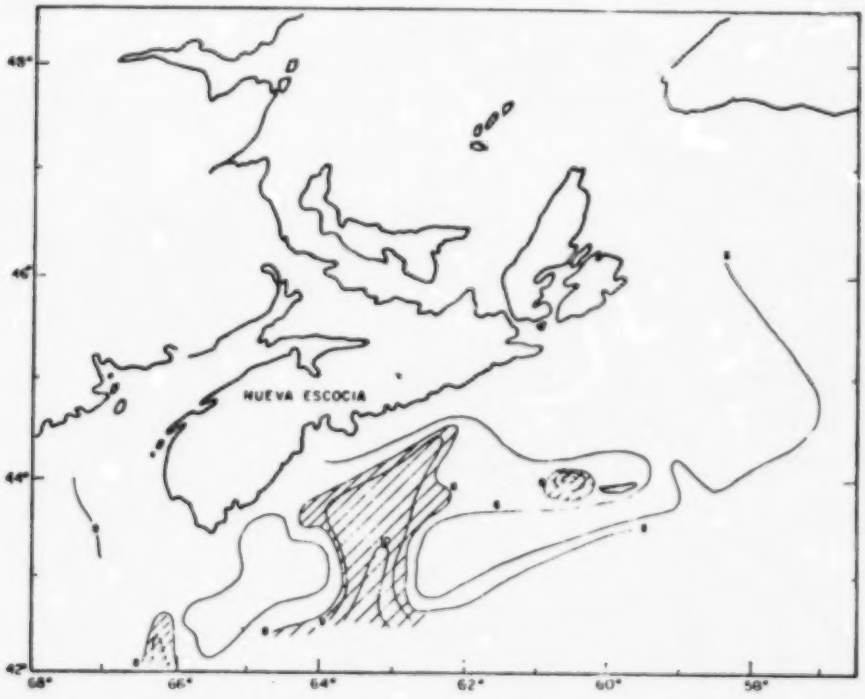


Fig. 3. T°C y áreas de aguas cálidas en el fondo - 1971.

Fig. 3. T°C and areas with warm bottom waters - 1971.

Fig. 3. T°C y áreas de aguas cálidas en el fondo - 1971.

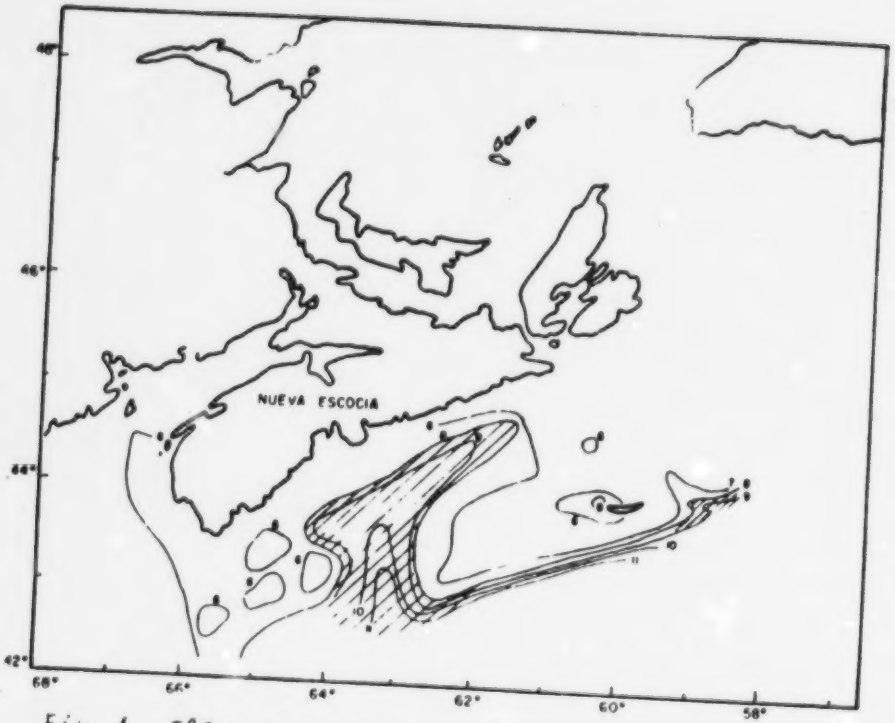


Fig. 4. T°C y áreas de aguas cálidas en el fondo - 1972.

Fig. 4. T°C and areas with warm bottom waters - 1972

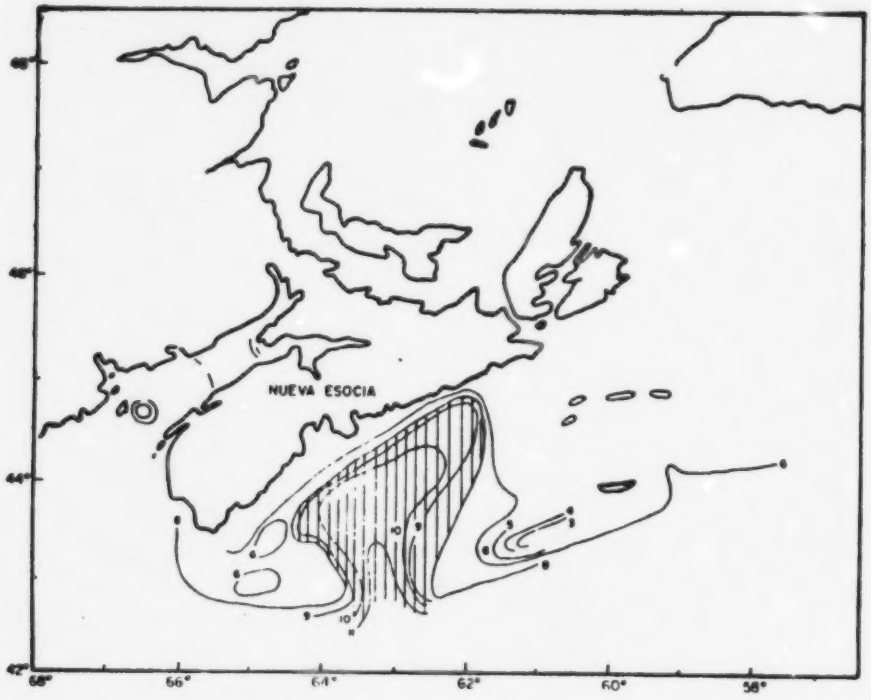
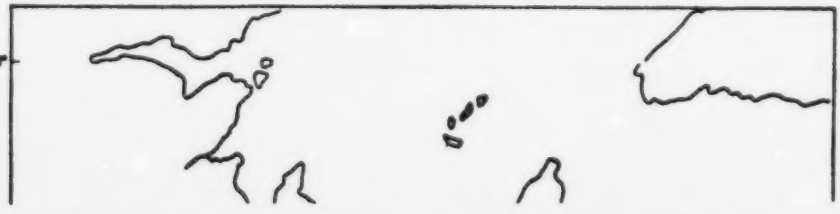


Fig. 5. T°C y áreas de aguas cálidas en el fondo - 1973.

T°C and areas with warm bottom waters - 1973.



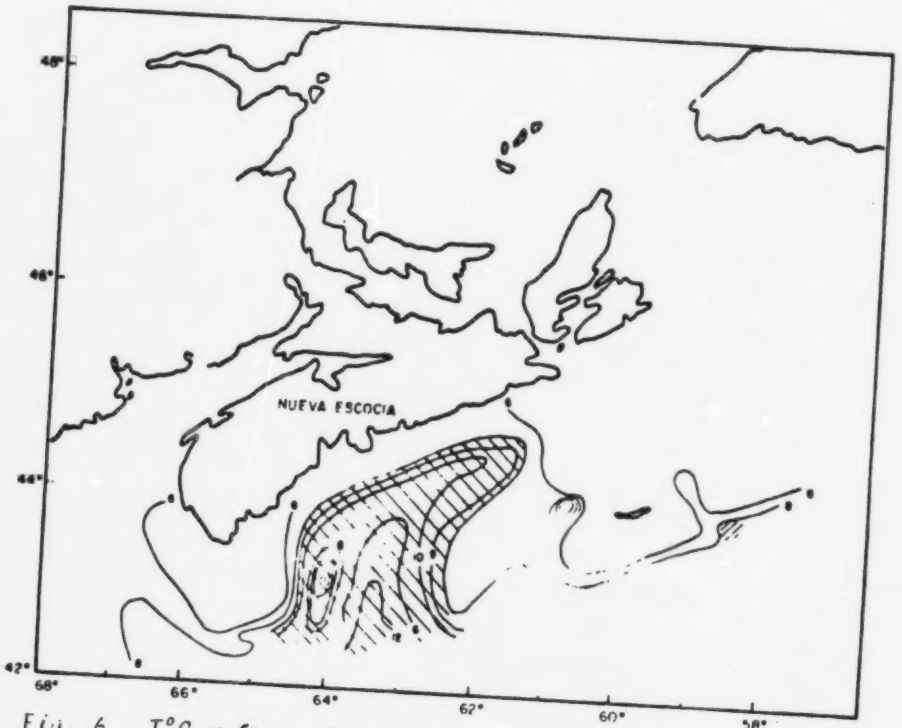


Fig. 6. T°C y áreas de aguas cálidas en el fondo - 1974.

T°C and areas with warm bottom waters - 1974.

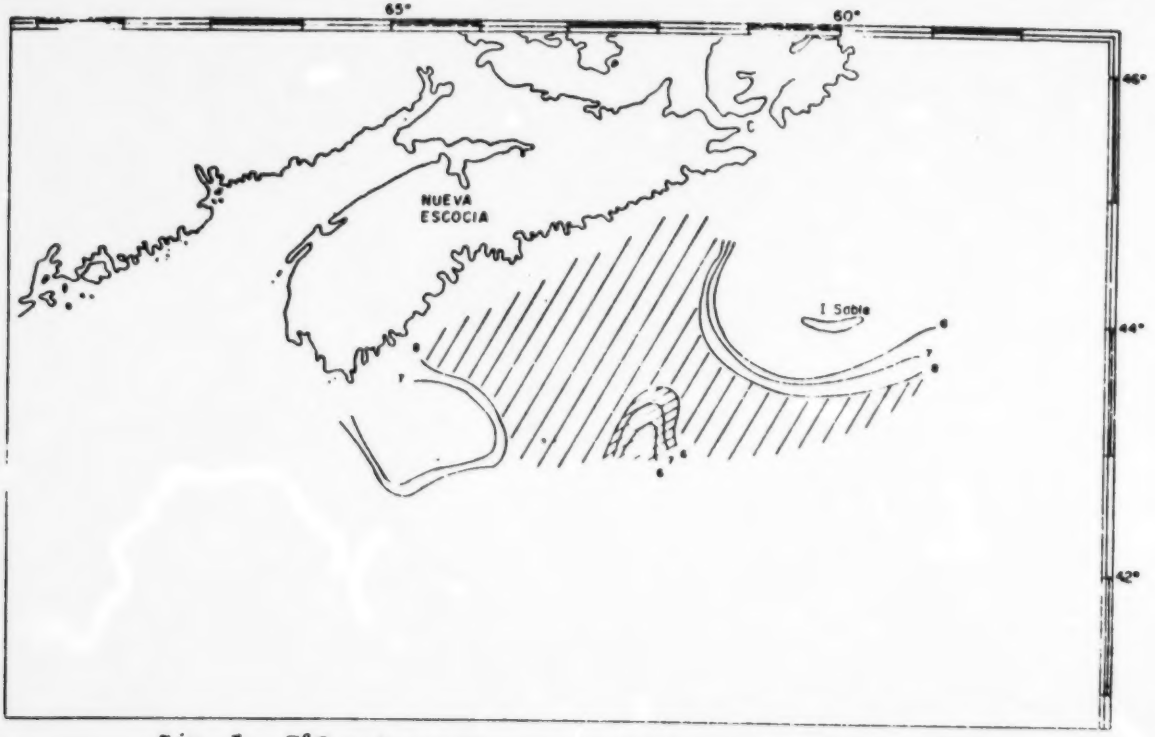


Fig. 7. T°C y áreas de aguas cálidas en el fondo - 1976.

T°C and areas with warm bottom waters - 1976.

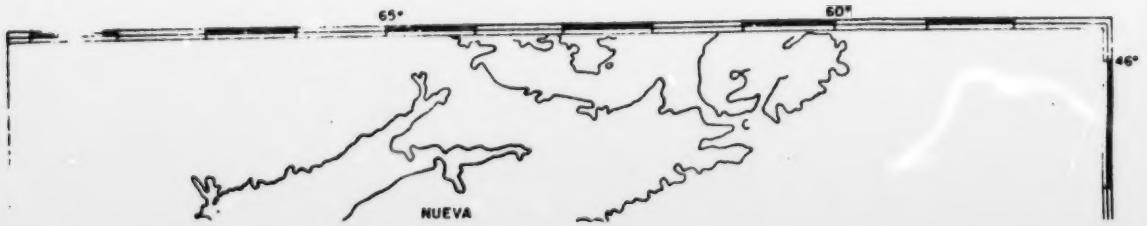


Fig. 8. T°C y áreas de aguas cálidas en el fondo - 1976.

T°C and areas with warm bottom waters - 1976. [sic but probably should read 1977]

Fig. 9. T°C y áreas de aguas cálidas en el fondo - 1978.
T°C and areas with warm bottom waters - 1978.

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RESUMEN.

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ABSTRACT.

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